

**WHAT IS CLAIMED IS:**

1           1. A method for determining a parameter for a piezoelectric actuator, the  
2 method comprising:  
3           controlling a drive signal applied to the piezoelectric actuator;  
4           operating the piezoelectric actuator;  
5           obtaining a feedback signal from the piezoelectric actuator;  
6           using the feedback signal to determine a parameter of the piezoelectric actuator.

1           2. The method of claim 1, wherein the step of operating the piezoelectric  
2 actuator comprises using the piezoelectric actuator to pump fluid in a pump

1           3. The method of claim 1, further comprising:  
2           controlling the drive signal so that an ascertainable electrical charge is applied to  
3 the piezoelectric actuator;  
4           obtaining a voltage value from the feedback signal;  
5           using the electrical charge and the voltage value from the feedback signal to  
6 determine capacitance of the piezoelectric actuator

1           4. The method of claim 3, further comprising:  
2           deriving the drive signal from a pulse width modulated signal;  
3           controlling pulse widths of the pulse width modulated signal so that the  
4 ascertainable electrical charge is applied to the piezoelectric actuator.

1           5. The method of claim 1, further comprising subsequently using the parameter  
2 of the piezoelectric actuator to control the drive signal to the piezoelectric actuator.

1           6. The method of claim 5, further comprising subsequently using the parameter  
2 of the piezoelectric actuator to control pulse widths of a pulse width modulated signal  
3 from which the drive signal is derived.

1           7. The method of claim 1, further comprising:  
2           varying the drive signal through a range of excitation frequencies;  
3           obtaining a voltage value from the feedback signal for each of the excitation  
4 frequencies;

5 determining a resonant frequency of the piezoelectric actuator as corresponding  
6 to a frequency in the range that had a minimum voltage value from the feedback signal.

1 8. The method of claim 7, further comprising determining the resonant  
2 frequency of the piezoelectric actuator as corresponding to the frequency in the range  
3 that had a minimum peak voltage value from the feedback signal.

1 9. The method of claim 1, further comprising:  
2 varying the drive signal;  
3 monitoring the feedback signal as the drive signal is varied for an “echo”;  
4 determining a resonant frequency of the piezoelectric actuator as an inverse of a  
5 period of the echo.

1 10. The method of claim 9, further comprising varying the drive signal through  
2 a step function.

1 11. A drive circuit which senses a parameter of a piezoelectric actuator  
2 operating in a device and which adjusts a drive signal of the piezoelectric actuator in  
3 accordance with the parameter.

1 12. The drive circuit of claim 11, wherein the drive circuit comprises:  
2 a controller which controls a drive signal applied to the piezoelectric actuator;  
3 a feedback monitor which obtains a feedback signal from the piezoelectric  
4 actuator while the piezoelectric actuator operates;  
5 a processor which uses the feedback signal to determine the parameter of the  
6 piezoelectric actuator.

1 13. The drive circuit of claim 12, wherein the device is a pump and wherein the  
2 piezoelectric actuator operates to pump fluid in the pump.

1 14. The apparatus of claim 12, wherein the controller controls the drive signal  
2 so that an ascertainable electrical charge is applied to the piezoelectric actuator;  
3 wherein the feedback monitor obtains a voltage value from the feedback signal; and  
4 wherein the processor uses the electrical charge and the voltage value from the  
5 feedback signal to determine capacitance of the piezoelectric actuator.

1           15. The apparatus of claim 14, wherein the drive circuit derives the drive signal  
2 from a pulse width modulated signal; and wherein the controller controls pulse widths  
3 of the pulse width modulated signal so that the ascertainable electrical charge is applied  
4 to the piezoelectric actuator.

1           16. The apparatus of claim 12, wherein the controller subsequently uses the  
2 parameter of the piezoelectric actuator to control the drive signal to the piezoelectric  
3 actuator.

1           17. The apparatus of claim 16, wherein the controller subsequently uses the  
2 parameter of the piezoelectric actuator to control pulse widths of a pulse width  
3 modulated signal from which the drive signal is derived.

1           18. The apparatus of claim 12, wherein the controller varies the drive signal  
2 through a range of excitation frequencies; and wherein the output monitor obtains a  
3 voltage value from the feedback signal for each of the excitation frequencies; and  
4 wherein the processor determines a resonant frequency of the piezoelectric actuator as  
5 corresponding to a frequency in the range that had a minimum voltage value from the  
6 feedback signal.

1           19. The apparatus of claim 18, wherein the processor determines the resonant  
2 frequency of the piezoelectric actuator as corresponding to the frequency in the range  
3 that had a minimum peak voltage value from the feedback signal.

1           20. The apparatus of claim 12, wherein the controller varies the drive signal;  
2 wherein the output monitor obtains the feedback signal as the drive signal is varied for  
3 an “echo”; and wherein the processor determines a resonant frequency of the  
4 piezoelectric actuator as an inverse of a period of the echo.

1           21. The apparatus of claim 20, wherein the controller varies the drive signal  
2 through a step function.

1           22. The drive circuit of claim 12, wherein the drive circuit comprises:  
2 means for controlling a drive signal applied to the piezoelectric actuator;

3 means for obtaining a feedback signal from the piezoelectric actuator while the  
4 piezoelectric actuator operates;

5 means for using the feedback signal to determine a parameter of the piezoelectric  
6 actuator.

1 23. The apparatus of claim 22, wherein the means for controlling controls the  
2 drive signal so that an ascertainable electrical charge is applied to the piezoelectric  
3 actuator; wherein means for obtaining obtains a voltage value from the feedback signal;  
4 and wherein the means for using uses the electrical charge and the voltage value from  
5 the feedback signal to determine capacitance of the piezoelectric actuator.

1 24. The apparatus of claim 22, wherein means for using determines the resonant  
2 frequency of the piezoelectric actuator as corresponding to the frequency in the range  
3 that had a minimum peak voltage value from the feedback signal.

1 25. The apparatus of claim 22, wherein the means for controlling varies the  
2 drive signal; wherein means for obtaining obtains the feedback signal as the drive  
3 signal is varied for an “echo”; and wherein the means for using determines a resonant  
4 frequency of the piezoelectric actuator as an inverse of a period of the echo.

1 26. A piezoelectrically-actuated device comprising:  
2 a piezoelectric actuator which is responsive to a drive signal for pumping fluid  
3 between the inlet and outlet; and  
4 a drive circuit which senses a parameter of the piezoelectric actuator and which  
5 adjusts a drive signal of the piezoelectric actuator in accordance with the parameter.

1 27. The apparatus of claim 26, wherein the device is a pump having a pump  
2 body for at least partially defining a pumping chamber having an inlet and an outlet  
3 which communicate with the pumping chamber, and wherein the piezoelectric actuator  
4 pumps fluid between the inlet and outlet.

1  
2 28. The apparatus of claim 26, wherein the drive circuit comprises:  
3 a controller which controls a drive signal applied to the piezoelectric actuator;  
4 a feedback monitor which obtains a feedback signal from the piezoelectric  
5 actuator while the piezoelectric actuator operates;

6 a processor which uses the feedback signal to determine a parameter of the  
7 piezoelectric actuator.

1 29. The apparatus of claim 28, wherein the controller controls the drive signal  
2 so that an ascertainable electrical charge is applied to the piezoelectric actuator;  
3 wherein the feedback monitor obtains a voltage value from the feedback signal; and  
4 wherein the processor uses the electrical charge and the voltage value from the  
5 feedback signal to determine capacitance of the piezoelectric actuator.

1 30. The apparatus of claim 29, wherein the drive circuit derives the drive signal  
2 from a pulse width modulated signal; and wherein the controller controls pulse widths  
3 of the pulse width modulated signal so that the ascertainable electrical charge is applied  
4 to the piezoelectric actuator.

1 31. The apparatus of claim 28, wherein the controller subsequently uses the  
2 parameter of the piezoelectric actuator to control the drive signal to the piezoelectric  
3 actuator.

1 32. The apparatus of claim 31, wherein the controller subsequently uses the  
2 parameter of the piezoelectric actuator to control pulse widths of a pulse width  
3 modulated signal from which the drive signal is derived.

1 33. The apparatus of claim 28, wherein the controller varies the drive signal  
2 through a range of excitation frequencies; and wherein the output monitor obtains a  
3 voltage value from the feedback signal for each of the excitation frequencies; and  
4 wherein the processor determines a resonant frequency of the piezoelectric actuator as  
5 corresponding to a frequency in the range that had a minimum voltage value from the  
6 feedback signal.

1 34. The apparatus of claim 33, wherein the processor determines the resonant  
2 frequency of the piezoelectric actuator as corresponding to the frequency in the range  
3 that had a minimum peak voltage value from the feedback signal.

1 35. The apparatus of claim 28, wherein the controller varies the drive signal;  
2 wherein the output monitor obtains the feedback signal as the drive signal is varied for

3 an “echo”; and wherein the processor determines a resonant frequency of the  
4 piezoelectric actuator as an inverse of a period of the echo.

1 36. The apparatus of claim 35, wherein the controller varies the drive signal  
2 through a step function.